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Investigation of the usability of the shock index in the prediction of mortality in stroke patients

Shock index in the prediction of mortality in stroke patients

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Abstract
Aim: Stroke is a neurological emergency and is an important cause of mortality and morbidity if not diagnosed and treated effectively. The shock index (SI) is obtained by dividing the heart rate by the systolic blood pressure. The aim of this study was to examine the efficacy of SI in predicting 30-day mortality in patients admitted to the emergency department (ED) and diagnosed with acute stroke.
Material and Methods: This study was single-center and conducted retrospectively and observationally. Patients who were admitted to ED and diagnosed with acute stroke between January 1 and July 1, 2022 were included in the study. Vital signs, comorbid diseases and mortality status of the patients were analyzed.
Results: The study included 246 patients with the mean age of 70.9 years, and 54.5% of them were women. As a result of the statistical analysis, SI was found to be statistically significant in predicting 30-day mortality ($p<0.001$). When the cut-off value of SI in determining 30-day mortality was >0.75, sensitivity was 69.7%, specificity was 95.8%, positive predictive value was 71.9 and negative predictive value was 95.3.
Discussion: SI is a non-invasive, inexpensive and simple estimation tool that can be easily calculated from only vital signs and can be used to predict mortality in patients with acute stroke.

Keywords
Mortality, Shock Index, Stroke

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Introduction

Stroke is one of the leading causes of disability and mortality in adults worldwide. In 2019, stroke was the second leading cause of death (6.6 million people) and disability (143 million disability-adjusted life years lost [DALYs]) worldwide [1,2]. Stroke is also the second leading cause of death in Turkey. The incidence of stroke in Turkey has been reported as 177/100,000 and its prevalence as 254/100,000 [3].

In acute ischemic stroke, it is of great importance that the treatments used can be administered as soon as possible after the onset of symptoms in order to be more effective. Intravenous (IV) thrombolysis and mechanical thrombectomy, which are the main treatment modalities, are effective time-dependent treatments. When IV thrombolytic therapy is started within the first 4.5 hours of acute ischemic stroke, and mechanical thrombectomy is performed within the first 6 hours of acute ischemic stroke, the efficacy and safety are proven treatments [4,5]. However, delayed treatment causes an increased risk of disability and mortality.

Early detection of patients requiring critical care in emergency departments (ED) is very important. For this purpose, various risk-scoring systems and estimation tools are used [6,7]. The shock index (SI) is one of these estimation tools. SI, which can be simply calculated as the ratio of heart rate to systolic blood pressure, provides important information about hemodynamics and tissue perfusion. There are many studies reporting that SI can be used to predict the prognosis of many diseases such as gastrointestinal bleeding, pulmonary embolism, and COVID-19 so far [8-10].

The aim of this study is to examine the relationship between SI at admission and the 30-day mortality status of patients admitted to ED and diagnosed with acute ischemic stroke.

Material and Methods

This retrospective observational study was conducted in the ED of a tertiary hospital between January 1 and July 1, 2022. Ethics committee approval for the study was obtained from the Fatih Sultan Mehmet Education and Research Hospital with the date 08.12.2022 and the number FSMEAH-KAEK 2022/108.

All patients over the age of 18 who applied to ED and were diagnosed with acute stroke within the date period determined for the study were included in the study. Patients under the age of 18, patients with a diagnosis other than acute stroke, patients whose SI could not be calculated at the time of admission, patients transferred from another hospital, and patients whose 30-day mortality status could not be reached were excluded from the study. Using the hospital electronic recording system, the patients' heart rate, systolic blood pressure, diastolic blood pressure, age, gender, comorbid diseases, treatments applied and the last diagnosis of the patients were recorded in a data set. The SI was calculated as heart rate divided by systolic blood pressure. The national electronic-based 'Death Notification System' was used to reach the 30-day mortality status of the patients.

The primary outcome of the study was to examine the relationship between 30-day mortality and SI at admission in patients diagnosed with stroke.

Statistical analysis

Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences) version 22 (IBM Inc. Chicago, IL, USA). Frequency (%), mean value, standard deviation, highest and lowest values were used for statistics. The Shapiro-Wilk and Kolmogorov-Smirnov tests were used to check the conformity of the data to the normal distribution. Non-parametric tests were used in the analysis since the data did not fit the normal distribution. The Chi-square test was used to compare qualitative data. ROC (receiver operating characteristic) curve analysis was used to determine the cutoff values of the AIMS65 and Rockall scores in predicting mortality. The optimal cutoff value, 95% confidence interval (CI), area under the curve (AUC), positive predictive value (PPV), and negative predictive value (NPV) were measured. The significance level was accepted as $p < 0.05$.

Ethical Approval

Ethics Committee approval for the study was obtained.

Results

The data of 265 patients diagnosed with acute stroke were analyzed. Seven of these patients were not included in the study because they were transferred from another hospital, in 9 patients, the SI could not be calculated at the time of admission, and the mortality status of 3 patients could not be reached. The study was completed with 246 patients. The patients were divided into two groups as survivor and non-survivor, and their various characteristics were compared with each other (Table 1). The mean age of the patients was 70.9 years, and 54.5% of them were women. There was no significant difference between the groups in terms of age and gender (p:0.277 and p:0.993). While the mean systolic and diastolic blood pressures of the non-survivor group were lower, the mean heart rate was found to be higher (p<0.001, p:0.002, p<0.001, respectively). It was determined that the mean SI in the non-survivor group was statistically higher than in the survivor group (p<0.001) (Table 1).

ROC analysis was used to determine the power of SI to predict 30-day mortality. As a result of the ROC analysis, the area under

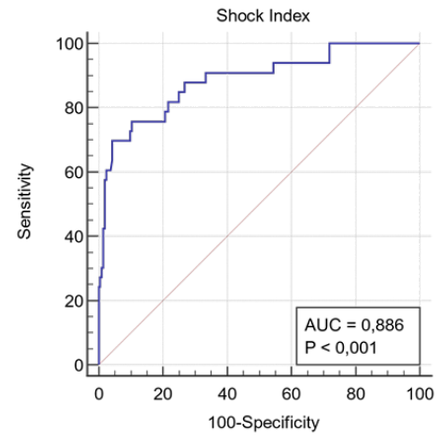

Figure 1. Receiver operating characteristic curve for predicting 30-day mortality using shock index.

Table 1. General characteristics of the enrolled patients.

	Non-survivor n:33		Survivor n:213		p value
	Mean	SD %	Mean	SD %	
Age	72.3	14.2	69.6	13.2	0.277
Gender					
Woman	97	45.5	15	45.5	0.993
Man	116	54.5	18	54.5	
Systolic blood pressure (mmHg)	131.8	30.0	162.4	30.5	0.001
Diastolic blood pressure (mmHg)	76.2	13.1	85.7	16.9	0.002
Heart rate (bpm)	101.7	20.8	80.7	15.8	0.001
Shock index	0.81	0.24	0.51	0.13	0.001
Hypertension	159	74.6	24	72.7	0.832
Diabetes Mellitus	73	34.3	12	36.4	0.845
Hyperlipidemia	14	6.6	3	9.1	0.709
Coronary artery disease	50	23.5	11	33.3	0.278
Thrombolytic	15	7.0	3	6.1	0.836
Thrombectomy	30	14.1	4	12.1	0.761

-Student's t-test – chi-square analysis

Table 2. Diagnostic values and cut-off level of the SI score to predict 30-day mortality in patients with acute stroke.

	AUC	Cut-Off	Sensitivity	Specificity	+LR	-LR	PPV	NPV	Youden Index
SI	0.886 (0.839-0.923)	>0.75	69.7	95.8	16.49	0.32	71.9	95.3	0.655

SI: shock index, AUC: area under curve, LR: Likelihood ratio PPV: positive predictive value, NPV: negative predictive value

the curve was determined as 0.886 (95% CI 0.839-0.923), the Youden index was 0.655, and the p-value was 0.001. As a result of the statistical analysis, SI was found to be statistically significant in predicting 30-day mortality (p<0.001). When the cut-off value of SI in determining 30-day mortality is >0.75; sensitivity was 69.7%, selectivity was 95.8%, positive predictive value was 71.9 and negative predictive value was 95.3 (Table 2, Figure 1).

Discussion

In this study, the relationship between SI at admission and 30-day mortality in patients diagnosed with acute stroke in ED was examined. It was concluded that a high SI at admission may be a useful tool in the prediction of mortality.

When the blood flow to a part of the brain is reduced or interrupted, the oxygen and nutrition of the brain tissue are impaired and the brain cells begin to die within minutes. This condition is defined as a stroke [11]. There are two specific types of stroke. While hemorrhagic stroke is caused by a rupture of a blood vessel in the brain; the ischemic stroke is caused by a blockage of an artery in the brain. Both conditions cause local hypoxia that damages brain tissue. Although both of them are serious and common, ischemic strokes are proportionally more common than hemorrhagic strokes [12]. Temporary or permanent loss of functions may occur in the area where the stroke occurred. Stroke is a frequently encountered condition in emergency departments with high mortality and morbidity. Therefore, it is an important disease that requires rapid diagnosis and treatment [13].

The SI is a prognostic tool that can be simply calculated from two bedside vital signs (heart rate and systolic blood pressure). It has been shown that SI shows left ventricular dysfunction especially secondary to hemorrhagic, septic or cardiogenic shock and is directly related to left ventricular stroke volume. There are many studies showing that SI can be used to predict mortality and intensive care requirement [14-16].

In our study, we concluded that an SI above the cut-off value of 0.75 can be used to predict 30-day mortality in stroke patients. There are very few studies on SI and stroke in the literature. Firstly, McCall et al. examined the relationship between SI and acute stroke mortality. In this multicenter study conducted in the UK, the data of 2121 stroke patients were examined, and it was concluded that both very low and very high SI values in these patients could be used to predict 3- and 7-day mortality [17]. In the study by Demir et al., a positive correlation was found between age SI and age-modified SI and in-hospital mortality in acute stroke patients [18]. Myint et al. investigated the relationship between SI at the time of admission and various outcomes (in-hospital mortality, length of hospital stay, discharge destination other than home, ambulatory status at the time of discharge, and poststroke disability) in 425,808 acute stroke patients. They reported that an SI value above 0.7 is associated with poor outcomes [19]. In light of this information, our study was found to be compatible with other studies in the literature.

This study has some limitations. First of all, the fact that the study was conducted from a single center caused the number of patients to be limited. The fact that this study is retrospective and the vital signs obtained were measured by different healthcare workers is one of the limitations of the study.

Conclusion

Stroke is a neurologic emergency and, if not diagnosed and treated effectively, it results in high mortality and morbidity rates. SI is a non-invasive, inexpensive and simple estimation tool that can be easily calculated from only vital signs and can be used to predict mortality in patients with acute stroke.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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